Black Carbon and Aerosol Analysis in Rain and Snow During SUPRECIP - 2

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Introduction:

Transport of Asian BC (Black Carbon) across the Pacific Ocean is significant during March and April *(Hadley et al. submitted June 2006)*

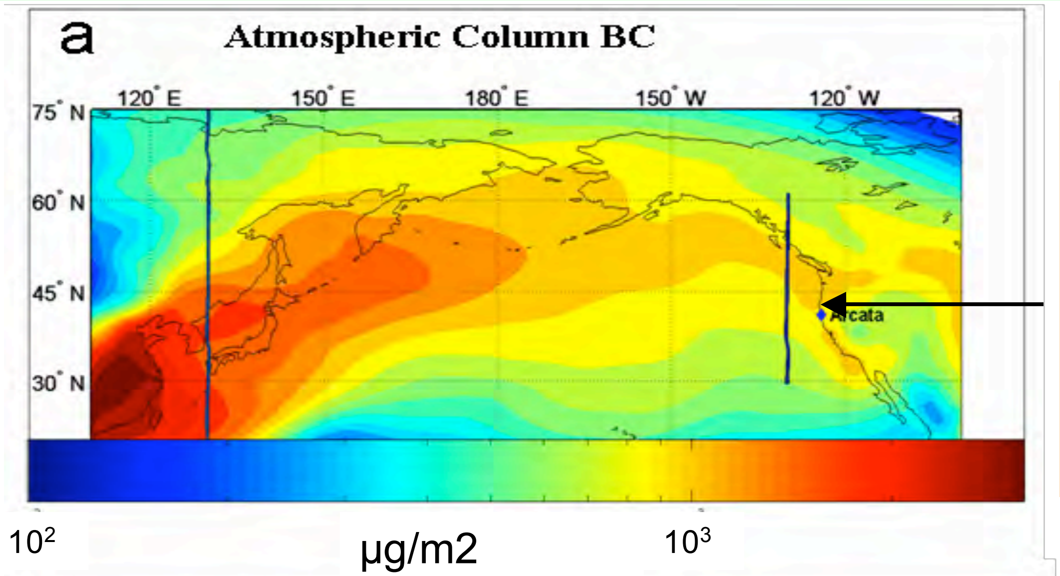
Transport occurs predominantly at higher elevations (>1 km) *(Heald et al. 2006)* and therefore may impact mountain snowpack albedo and melt rates *(Jacobson MZ, 2004; Hansen J and Nazarenko L, 2004;)*

We aim to measure the concentration of BC in falling snow and rain to:

(a) compare BC in coastal rainwater to inland mountain snow fall and

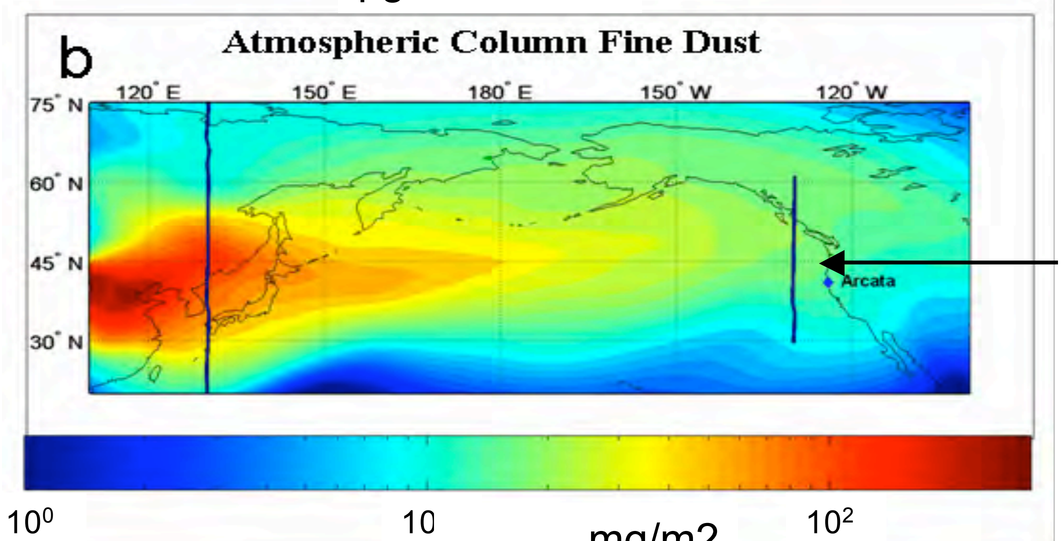
(b) determine if it is large enough to impact snowpack lifetime in the California mountains.

Motivations: Long range transport of aerosols
CFORS (Chemical FORecast System model - April 2004



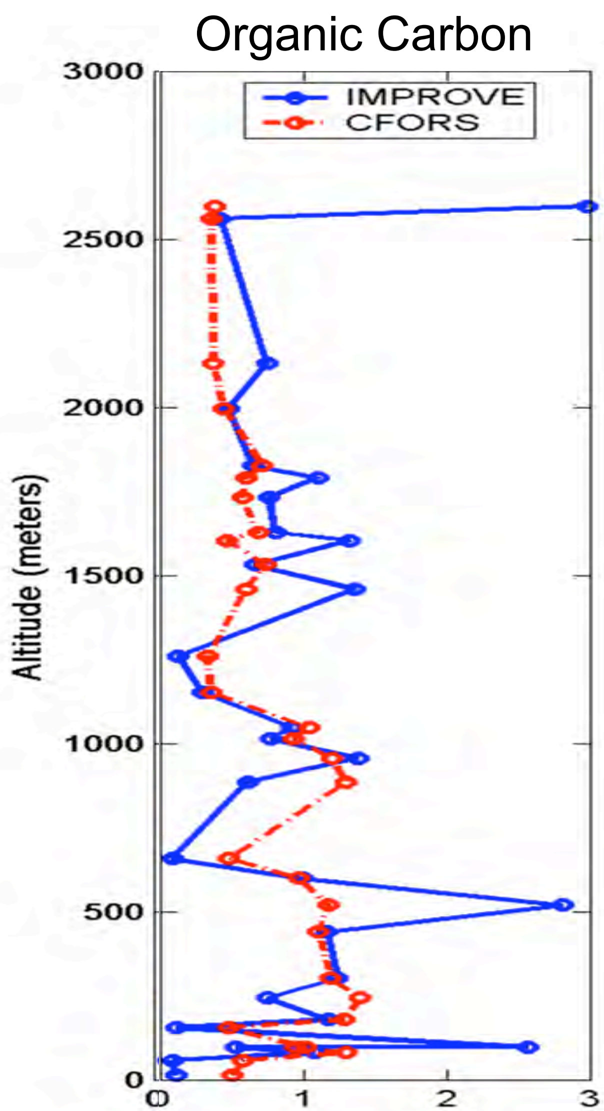
<u>BC total transport</u>
25 – 32 Ggrams

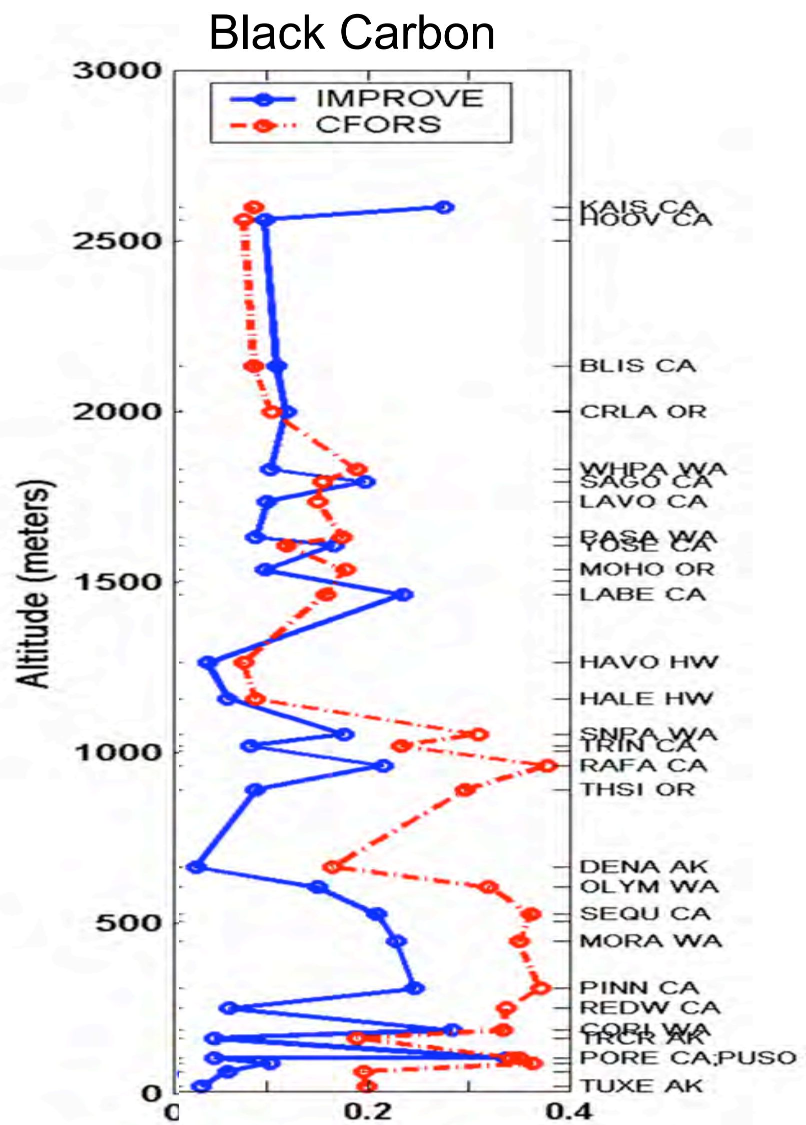
77% of estimated North American monthly BC emissions *(Hadley et al. subm. 2006)*



<u>Fine Mass transport</u>
900 – 1100 Ggrams

Predictions (CFORS) vs. observations





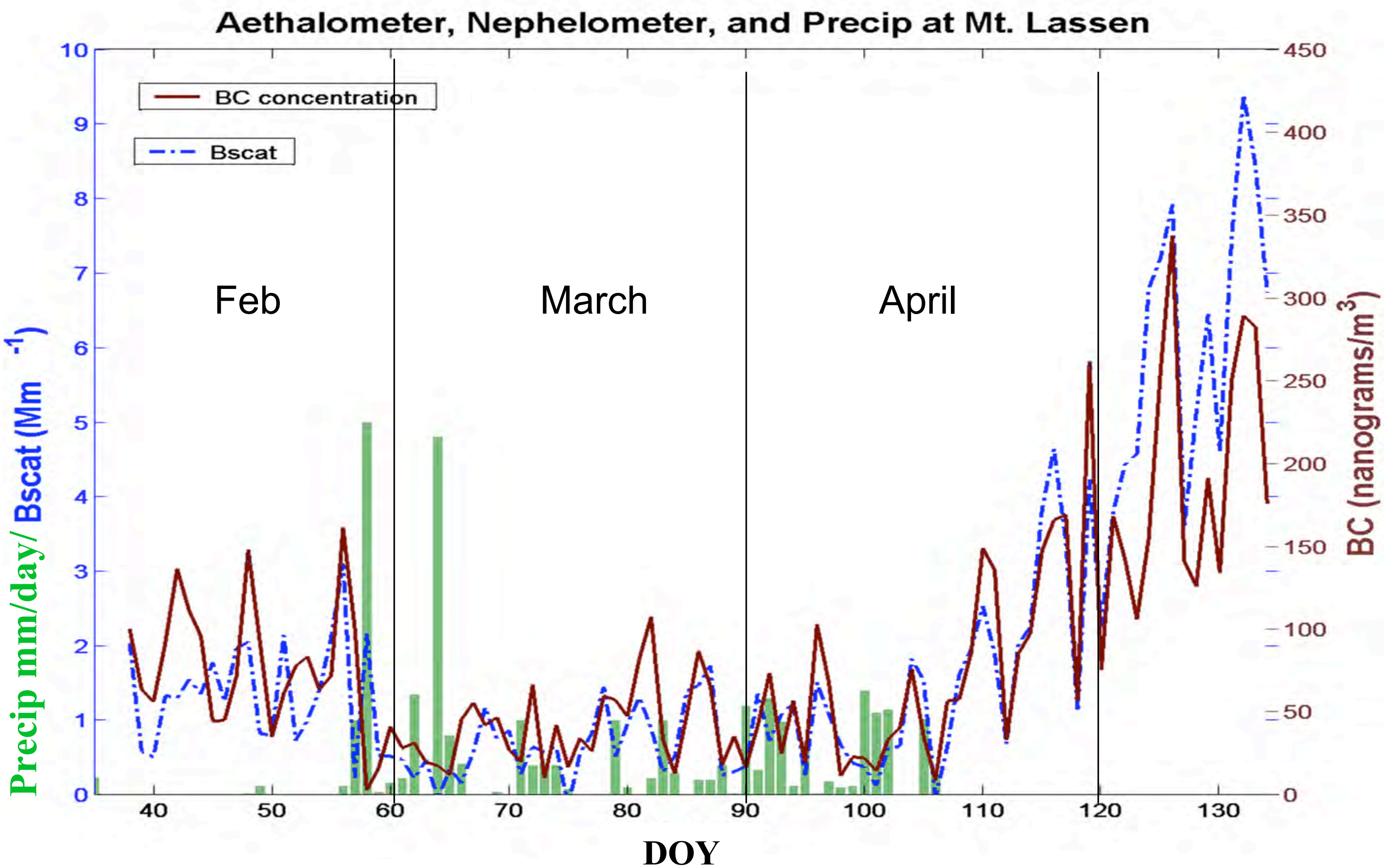
μg/m^3

Goals of the experiment

- **Measure black carbon concentration in snow and rain, both upwind and downwind of local pollution sources.**
  - **Are BC concentrations significant enough to enhance springtime melting of the mountain snow pack?**
- **Look at chemical components in the precipitation as an indicator of origin.**
  - **Could Asian aerosols be influencing snow melt?**


Trinidad Head
Redding
Lassen Vol. Pk.
(1732 m)
5
80
CSSL
(2100 m)
101
505
Sacramento
50
395
Mt. Tamalpais
(700 m)
680
580

Ambient BC and light scatter at Mt. Lassen Natl. Park 2006



Successful Snow Collection Season

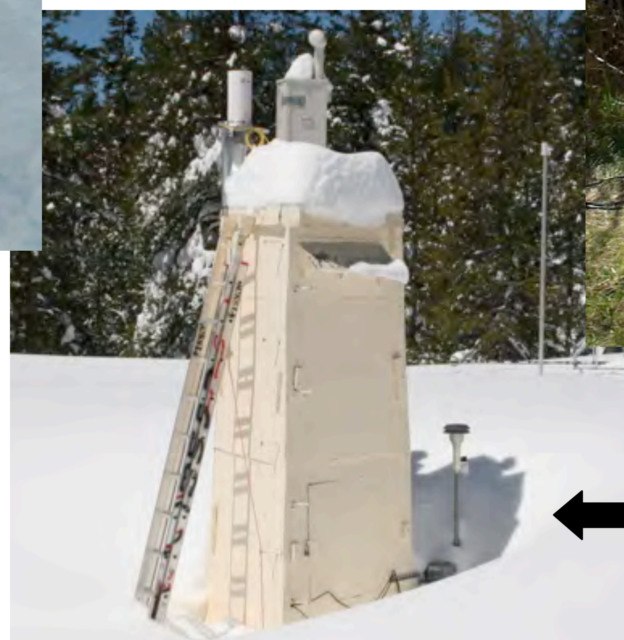
•Site in operation from Feb 26 to April 30th.

• Over 20 samples collected at CSSL

Lassen Volcano NP
02/06/2006 – 04/30/2006

Trinidad Head, Arcata

02/13/2006 – 04/30/2006

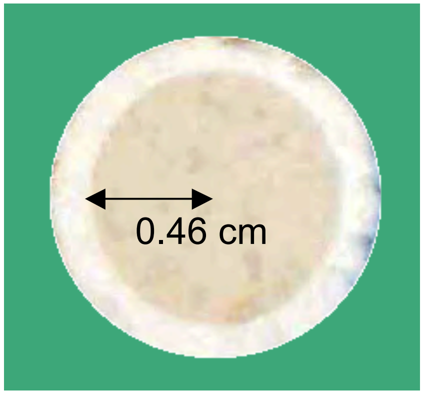


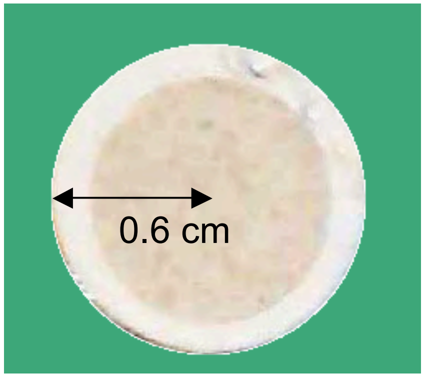
Central Sierra Snow Lab -
02/26/2006 – 04/30/2006

Over 80 samples collected at all 3 sites combined.

Black Carbon observed in Precipitation

- **200 mL of precipitation sample are vacuum filtered through quartz fiber filters.**
- **Color change indicates not only BC, but the presence of yellow or red dust in the rain sample.**





Accurate Measurements of Black Carbon are very Difficult to Make!!!

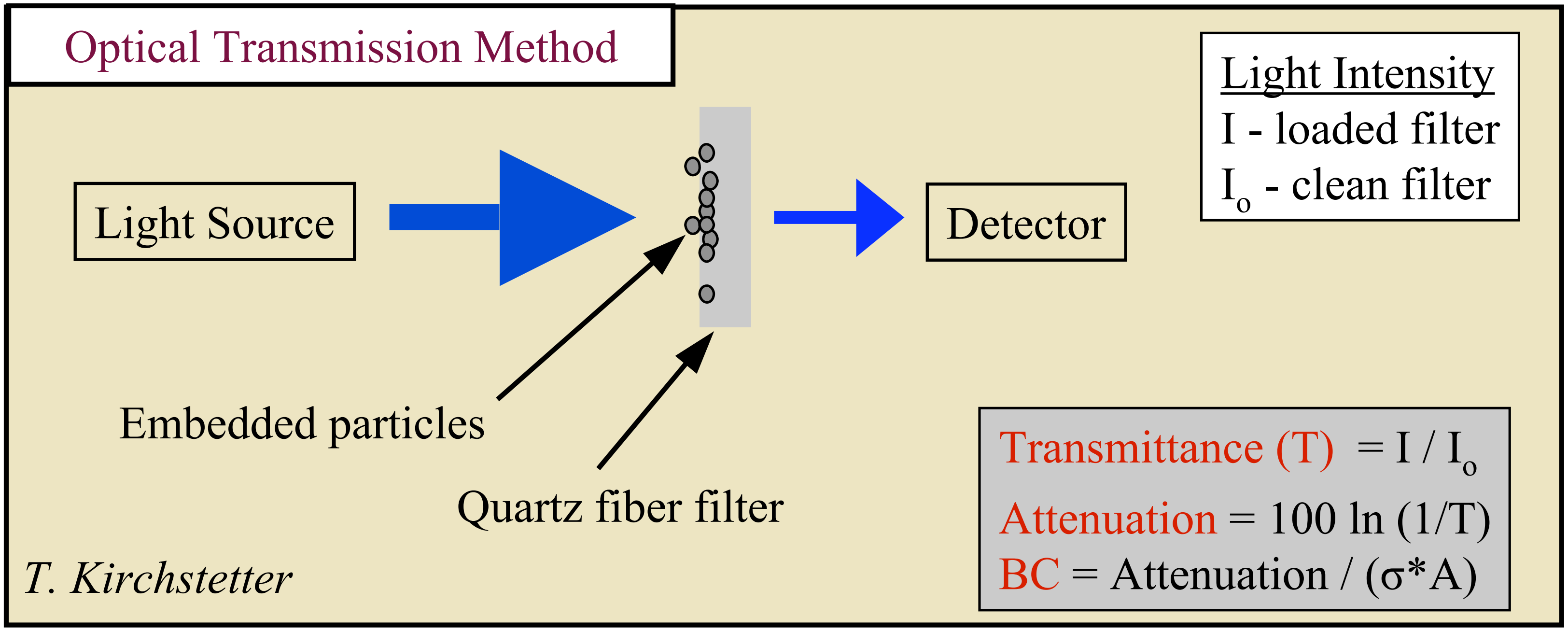
- We use 2 independent methods to determine BC concentration.
- Method 1: Evolved Gas Analysis
- Method 2: Spectral Light Transmission Method.

Method 1. Evolved Gas Analysis, Thermo-Optical Transmittance (EGA-TOT)

- **Filters are heated from 50ºC to 800ºC in an oxygenated atmosphere**
- **Organics are oxidized to CO_2 at T < ≈ 500ºC and BC or soot at T > ≈ 500ºC**

$$BC = \int_{T \approx 500^\circ C}^{T = 800^\circ C} \frac{\left(P_{CO_2}\left({}^{moles\ CO_2}\!/_{mole\ O_2}\right) * O_2\left({}^{moles}\!/_{L}\right) * 0.2\left({}^{L O_2}\!/_{\min}\right) * 12\left({}^{g}\!/_{mole\ C}\right)\right)}{\left(40\left({}^{\circ C}\!/_{\min}\right) * 1.15\right)} dT$$

Method 2. SLTM

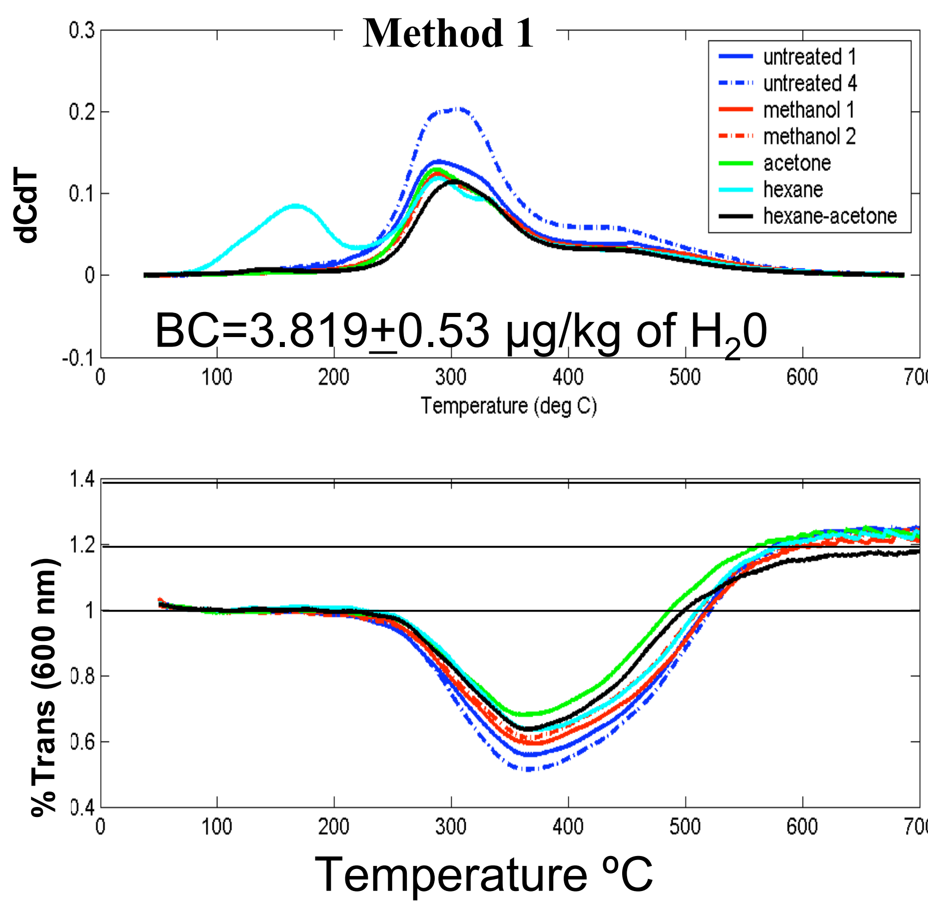


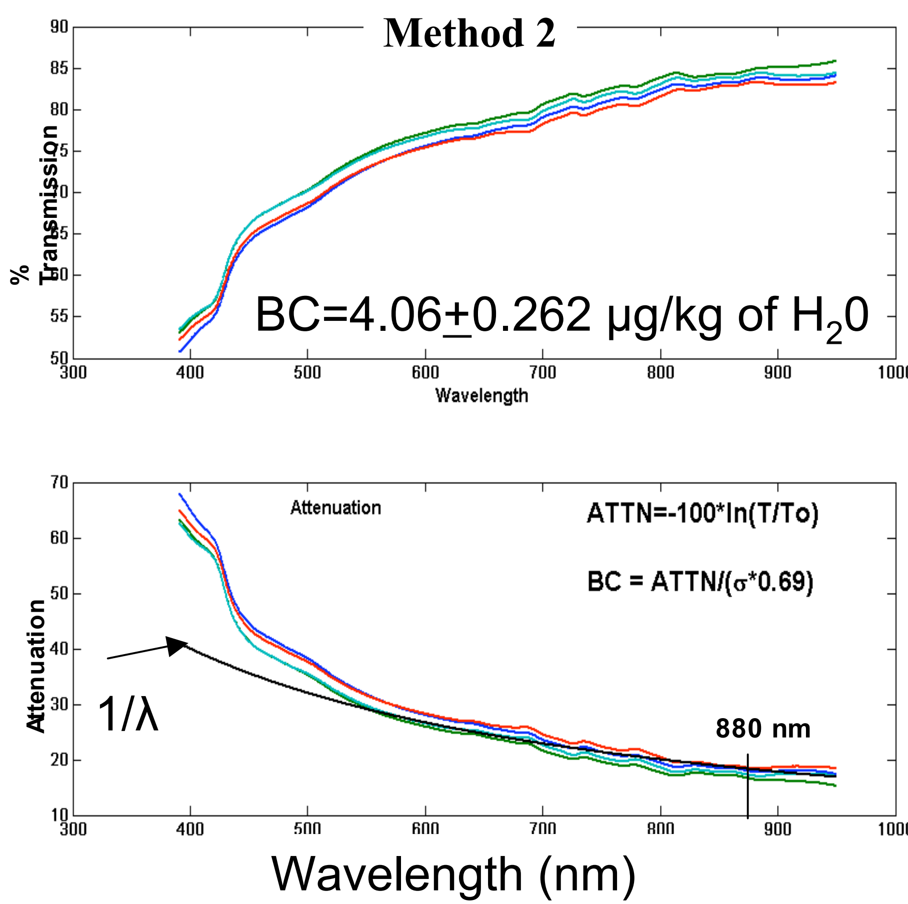
- **Method is sensitive mainly to particle light absorption, not scattering**
- **Widely used to measure aerosol light absorption: Aethalometer, Particle Soot Absorption Photometer (PSAP)**
- **Continuous light spectra from (370-1200 nm), BC mass is taken at 880 nm**
- **Sigma (mass absorption efficiency) is set at 20 $m^2 g^{-1}$; A = 0.69 m^2**

EGA-TOT vs. SLTM

Tested 7 filters made from Trinidad Head bulk gauge water bucket.

- **Standard deviation is 5% for SLTM and 13% for EGA-TOT.**
- **Agreement between the two methods is within 6%**





Challenges with measuring BC in Water

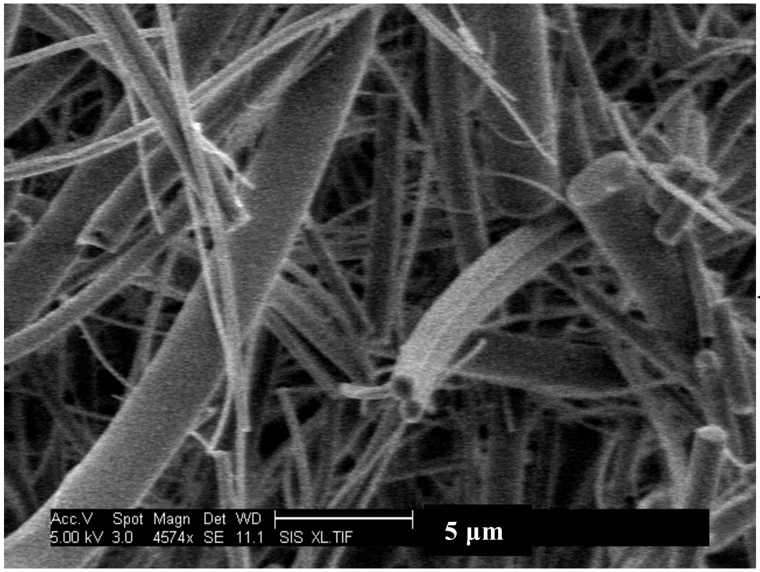
- **Determine efficiency of BC collection on the quartz fiber filter (these filters must be used for both types of analysis)**

  1. **Use SEM to look at sizes of particles that pass through the filter.**
  2. **Evaluate the efficiency of the filter using a known BC standard.**

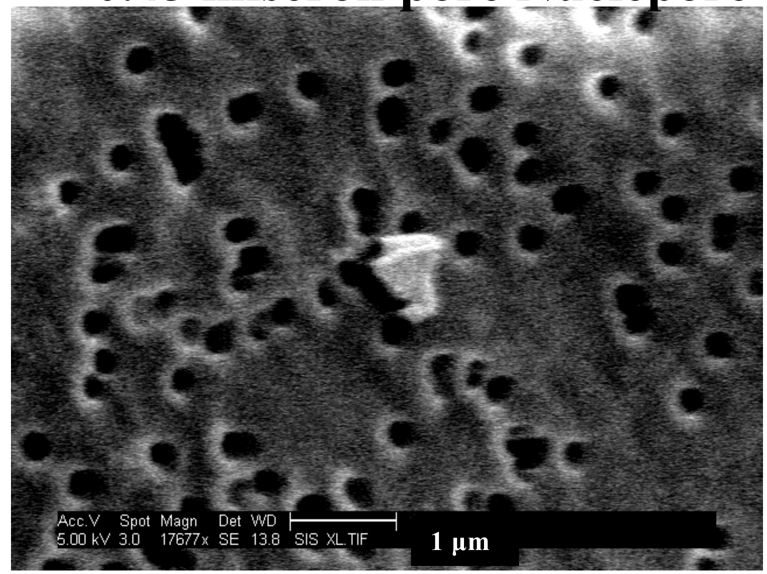
- **Evaluate BC losses to surfaces during collection and analysis**

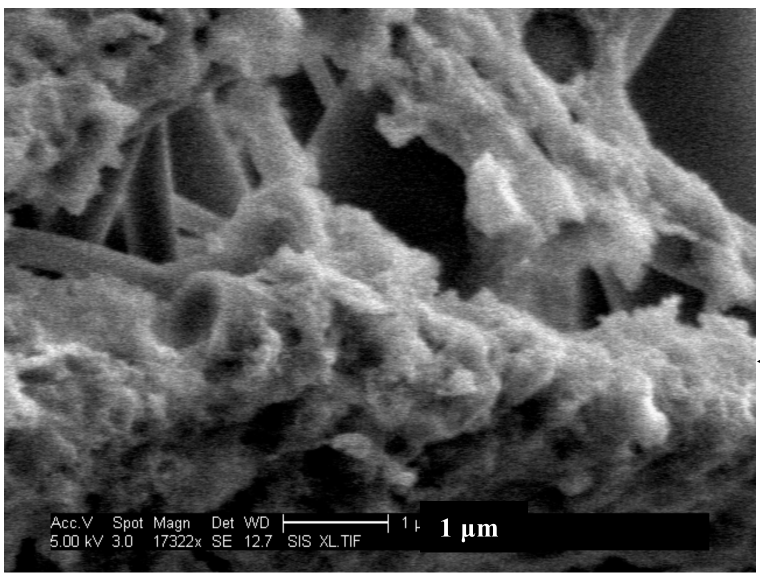
SEM images of Snow Melt from Lassen

Quartz Fiber **followed by** → **0.45 miscron pore Nuclepore**



← Clean





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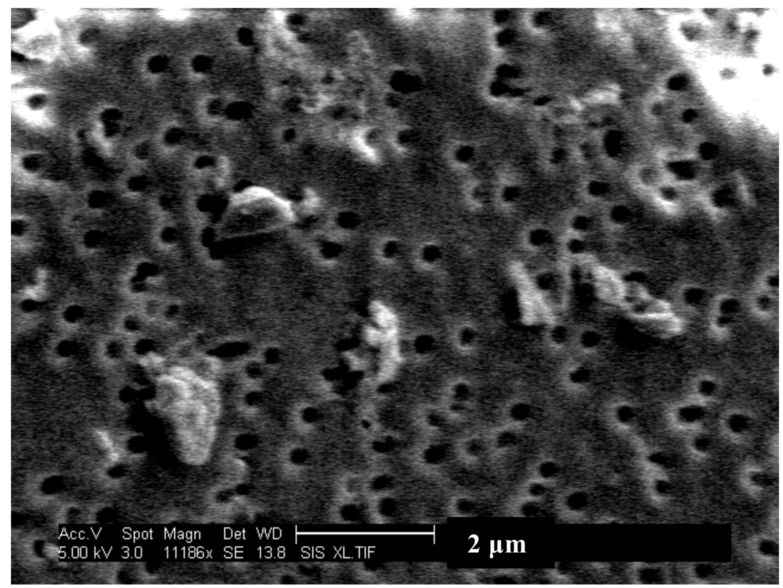
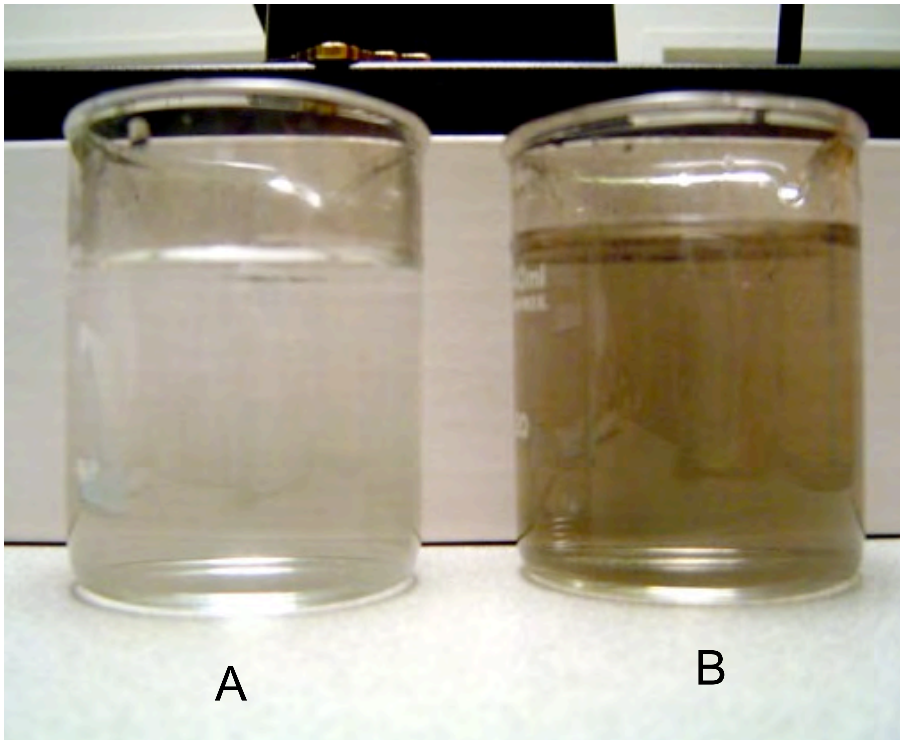


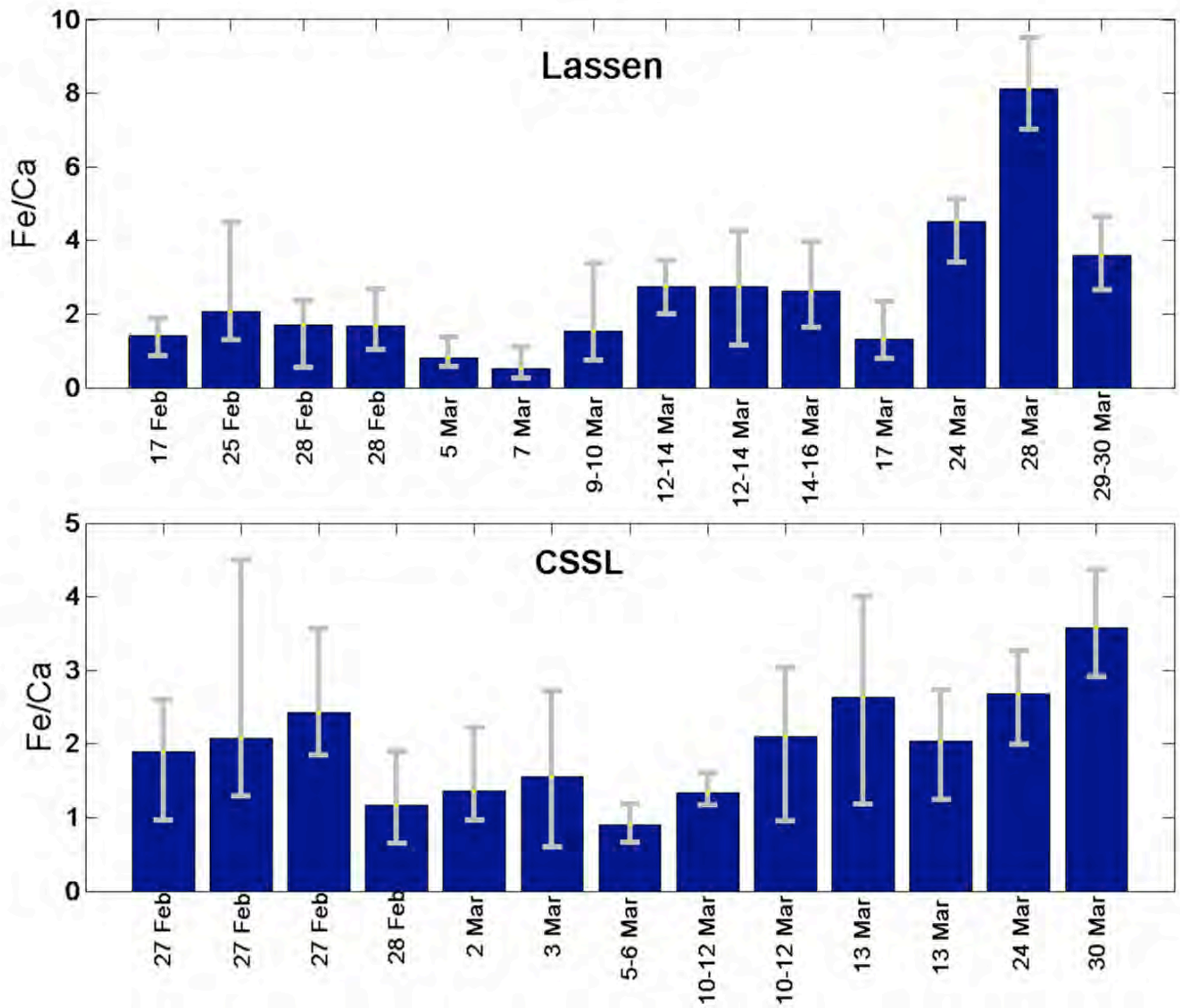
Standard for BC in water to calibrate filter efficiency



T. Kirchstetter's group 2006

- Standard is used to calibrate filter efficiency.
- To get a suspension of soot in water it must be artificially aged by reacting with ozone.
- The soot is then bubbled through distilled water to make the standard.
- A) no ozone
- B) ozone reacted

Mt. Lassen Volcano Natl. Park and Central Sierra Snow Lab: XRF analysis of snow melt water



Further work…

- Complete measurements of BC concentration in rainwater and snow meltwater.
- Compare the evolution of BC and elemental signatures as a storm moves from the coast to Sierras.
- Place BC concentrations into context with previous work on solar absorption by soot and enhanced snowpack melt.

Acknowledgements

California Energy Commission

Guido Franco - CEC

Daniel Rosenfeld - Institute of Earth Sciences
Hebrew University of Jerusalem

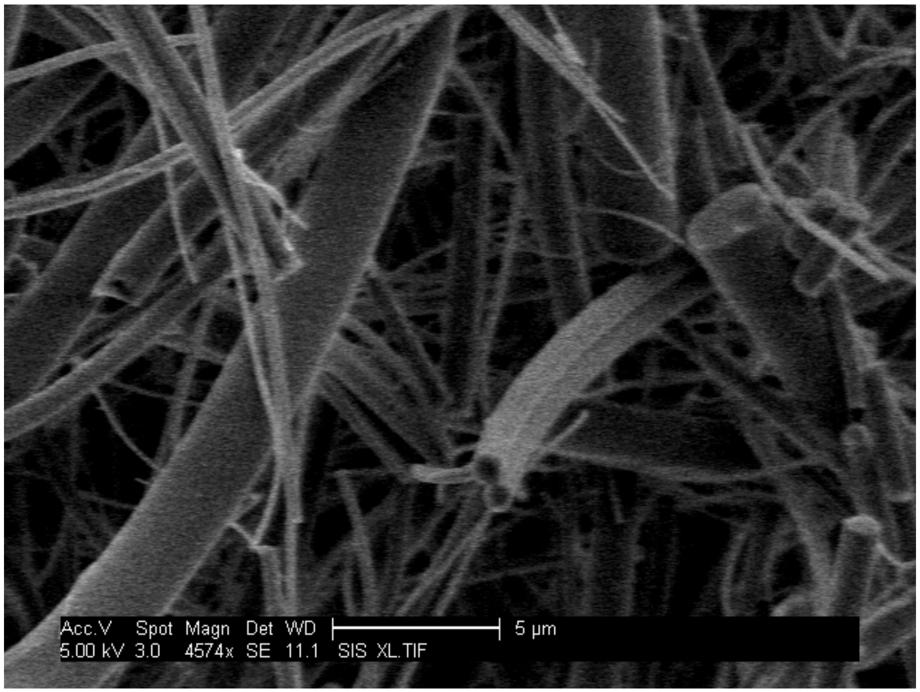
Steven Cliff - UC Davis.

Randall Osterhuber - Central Sierra Snow Lab.

Nancy Nordensten & Mike Magnusen - US Nat. Park Service

Mike Ives - Humboldt State Marine Lab

Tom Kirchstetter - Lawrence Berkeley Nat. Lab.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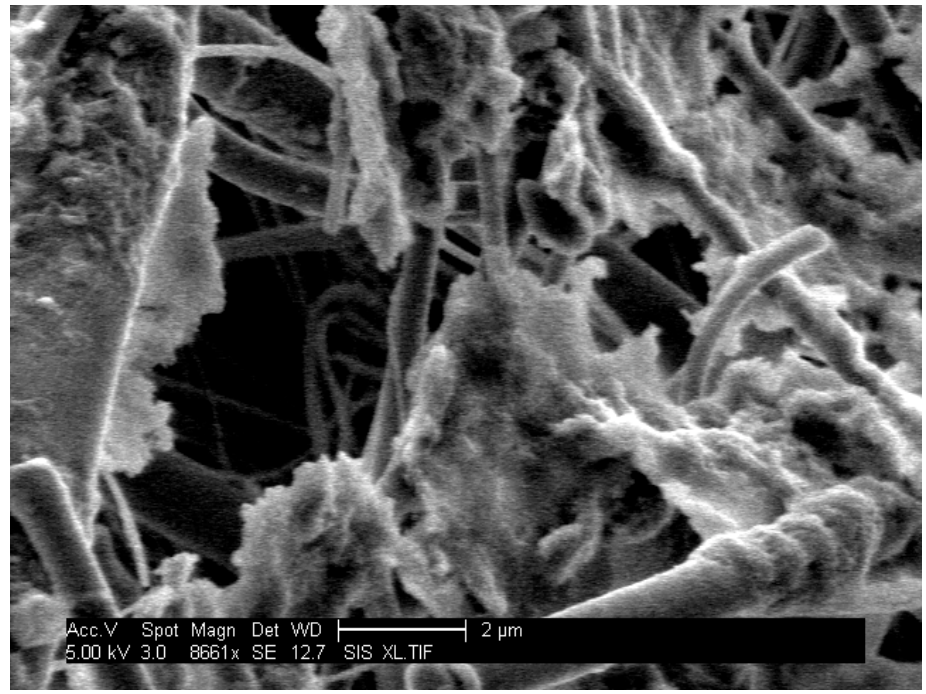
Acc.V Spot Magn Det WD
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